Puppets promoting engagement and talk in science

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Abstract

Research into classroom interactions has shown that talk that promotes reasoning can help children in their learning of science. Such talk can only be generated when teachers are willing to take a dialogic approach that is stimulating and provides opportunities for children to articulate their ideas. This research set out to determine whether the use of large puppets would help teachers to change the nature of their whole class discourse to enhance children's talk and engagement in science. The study was carried out with 16 teachers of children aged 7 to 11 years in schools in London and Manchester, UK. Through adopting a mixture of research methods, including classroom observation and teacher and child interviews, the research provides evidence that the use of puppets significantly increases the amount of teacher discourse oriented towards reasoning and argument, and decreases the amount of talk that focuses on recall. Through the puppets, teachers also use more narrative to set the science in stimulating contexts, and encourage children in their contributions to whole class discussion. Interview data also show the positive effects of puppets on children's motivation and engagement in science. The findings have led to further major funding for professional development in the use of puppets in the UK, and research into the reasons why the use of puppets is so effective.

Introduction and background

The value of talk in children's learning has been well-documented since our understanding and appreciation of Vygotsky's (1962,1978) work on language and social interaction. Building on Vygotsky's legacy, the importance of talk in classrooms has been highlighted through the evidence provided by Mercer and colleagues in their extensive research into

classroom interactions (e.g. Mercer, Wegerif & Dawes, 1999; Mercer, Dawes, Wegerif & Sams, 2004). These and other researchers have found that talking about their ideas helps children to clarify their thinking and develop their capacity to reason (Kuhn, Shaw & Felton, 1997; Venville, 2002). The induction of children into the use of 'exploratory talk' (Mercer et al., 1999), in which they engage critically but constructively with each other's ideas, has been shown to promote gains in children's non-verbal reasoning. Exploratory talk makes knowledge publicly accountable and reasoning visible; it is developed when children work collaboratively in groups, where they can confidently voice their opinions, be challenged and challenge the views of their peers. Such interactivity can provide a powerful stimulus to learning (Dawes, 2004).

Talk that promotes reasoning is particularly important in science education, since the ability to use reasoning is critical in the construction of scientific arguments (Kuhn, 1993; Wellington & Osborne, 2001). Developing the skills of argumentation is now recognised as an important process in children's learning about the nature of science (Osborne, Erduran & Simon, 2004), and providing opportunities for discussion and argumentation in science leads to greater engagement by learners (Ogborn, Kress, Martins & McGillicuddy, 1996). Talk and peer collaboration have also been shown to contribute to children's development of conceptual understanding in science (Howe, Tolmie, Duchak-Tanner & Rattray, 2000; Howe, McWilliam & Cross, 2005; Mercer et al., 2004).

Unfortunately the kind of talk that promotes reasoning is absent in many classrooms (Alexander, 2005) and there is little evidence of the prominence of talk in many science lessons (Lemke, 1990; Newton, Driver & Osborne, 1999). There are good reasons why teachers may provide limited opportunities for discussion and talk in science (Solomon, 1998); they may feel pressured by the weight of the science curriculum and view talk as an occasional add-on rather than as a central feature of learning, placing more value on written

work (Alexander 2005); they may not be aware of suitable stimulus material, since many science education resources focus on activity rather than talk; they may be uncertain about how to set up and manage talk in the classroom and uncertain about what role they should take while children are talking. In addition, many teachers may feel insecure in their science subject knowledge and prefer to stay firmly in control (Osborne & Simon, 1996), using a questioning style of initiation, response and feedback (IRF) that often fails to engage children or stimulate their thinking (Lemke, 1990). Recent research into argumentation in school science (Osborne et al., 2004) highlights the need for teachers to be supported in creating classroom circumstances in which children can develop their reasoning skills and use of evidence through talk.

The kind of talk that optimises learning is that which is mediated and supported by others, where individual thinking is developed through social interaction with more capable peers or teachers (Vygotsky, 1978). The research by Mercer and his colleagues (Mercer et al., 1999) confirms not just the value of focused and systematic talk in primary classrooms but also the central role of the teacher in promoting 'learning conversations'. In recent research that set out to investigate the effect of teacher intervention in science activities, Mercer et al. (2004) focus their study on two main contexts; teacher-led interactions and peer interactions. Their analysis of these two contexts provides evidence that scientific understanding can be assisted by a combination of peer group interaction and expert guidance. Alexander (2005) also focuses on the role of the teacher in providing opportunities for what he terms 'the right kind of talk' in 'dialogic teaching', in which teachers and children address learning tasks together and talk is reciprocal, supportive and purposeful. Such talk requires a suitable stimulus that engages children and provides an obvious opening for focused conversation between children. The right stimulus will also enable children to feel personally involved in the discussion, committed to the conversation and interested in the outcome.

Effective stimuli for generating talk in science classrooms include strategies such as classifying and grouping, concept cartoons, graphic organisers, predict-observe-explain and true-false statements. Examples of good strategies can be found in a range of sources (e.g. Naylor, Keogh & Goldsworthy, 2004; Wellington & Osborne, 2001; White & Gunstone, 1992) and our experience is that when teachers use such strategies children are typically self-motivated and their conversations can be self-sustaining. Yet given the difficulties teachers face in adopting new approaches, our aim was to find a further stimulating device that teachers would be willing to use that might have an immediate impact on their practice. We knew that one teaching strategy that had not previously featured in science was the use of large puppets that can be held by teachers and used to talk with children. There is evidence that such puppets can have a valuable impact in engaging children and promoting language development (Low & Matthew, 2000). The use of puppets is well-established in primary schools in drama and social education (Thorp, 2005) and puppets can also be especially important for promoting personal, social and emotional development in sensitive areas where strong personal feelings may be involved (Bentley, 2005). In the research reported here, we set out to investigate whether the use of puppets would provide a stimulus that would generate the kind of talk that helps reasoning in science. Through the puppets teachers could model behaviour and learning conversations without appearing to intervene as an authority figure. This modelling could include ground rules for talk (Wegerif, Mercer & Dawes, 1999), such as having a reason for what you say. Puppets could also allow teachers to take on new roles in the classroom and introduce new ideas so as to create cognitive conflict. For example, puppets could legitimise certain kinds of talk that do not normally feature within a teacher's repertoire, such as claiming to be confused or ignorant about a situation. Since puppets do not have the status or authority of the teacher they could be particularly useful in situations where children lack confidence in putting forward or defending their ideas, in the

same way that concept cartoons encourage children who are normally reluctant to express their ideas to engage in discussion and argument (Keogh and Naylor, 1999). Using puppets to present arguments might help children to engage in dialogue and to consider alternative perspectives on scientific ideas in a non-threatening situation.

Should these perceived benefits of using puppets be demonstrated through our research, then our work with puppets might help to address the low status of talk currently prevalent in UK classrooms, and help to address two fundamental questions posed by Alexander (2005, p.10): 'Do we provide and promote the right kind of talk; and how can we strengthen its power to help children think and learn even more effectively than they do?'. The research set out to find ways of enhancing the 'right kind of talk' by using puppets to promote discussion of science concepts and ideas in primary classrooms. The main research questions to be investigated were:

- Can puppets be used to enhance children's engagement and promote talk in science lessons?
- What is the impact on children's talk involving reasoning when puppets are used in science?
- What is the impact of using puppets on teachers' beliefs and practice in relation to talk?

Research design and data sources

The research was carried out with teachers in the Manchester/Cheshire area (the northwest region of England) and in London. Prior to beginning the funded research, we were fortunate to be able to undertake some preliminary work in which the viability of using puppets with different age groups could be explored. A group of trainee teachers studying with us expressed an interest in the research and were willing to explore the use of puppets. The

hand-held puppets were all human characters up to 66 cm in height (though sizes varied) and could be operated easily by teachers and children. A pilot phase was then undertaken with eight teachers (four in Manchester and four in London) in order to establish data collection methods and analytical frameworks for the main study, and to inform the guidance needed for teachers in the use of puppets. The main research and development phase subsequently involved a further 12 teachers in Manchester and four in London.

Pre-pilot and pilot phases

The innovative nature of the research suggested that pilot work was necessary. The use of puppets for teaching and learning in science was, to the best of our knowledge, an entirely new field of research and it was essential to test out some of the assumptions underlying the project and to develop a sound research methodology before the main phase of the research began. In the pre-pilot phase two groups of trainee teachers worked with puppets in primary schools with children aged 4 to 11 years. There was no systematic recording of data in this phase but classroom observations were made by members of the research team and meetings held with the trainee teachers and class teachers to share perceptions. The results from this phase indicated that the use of puppets could have positive outcomes in science lessons and led to some early decisions about the number and type of puppets to be used.

The teachers involved in the pilot phase were all considered by regional science advisors to be competent teachers, though none of them had any expertise in using puppets. A preparatory meeting was held in each location (Manchester and London) at which each teacher was provided with two puppets and some guidance on the logistics of using puppets, such as how to hold them and how to build the characters of the puppets. Teachers were also provided with some exemplar lesson plans and scenarios that could be used with puppets, based on the kinds of stimulating resources that were familiar with primary teachers, such as

concept cartoons (Naylor & Keogh, 2000). There followed a two-month period in which the teachers could become familiar with using puppets in their teaching. Each teacher was then observed and video-recorded using their puppets in a science lesson, and subsequently interviewed to establish their perceptions about the use of the puppets. In some pilot schools it was also possible to video-record interviews with the children to ascertain their views of the puppets. The video-recordings of lessons and interviews were observed and discussed by the research team, and fully transcribed. A follow-up evaluation meeting was held for teachers in each location to provide the opportunity for them to contribute to the next phase of development. Feedback from the teachers, from the research team and from children allowed perceptions to be shared, and the key issues to be discussed that would inform the main study.

From this pilot phase we found that puppets appeared to be most successful when posing problems and creating cognitive conflict for children. Teachers made the science problematic by creating a range of scenarios based around the everyday lives and emotions of the puppets. To the children these were authentic situations that readily connected with their own experiences. For example, one teacher using a single puppet, a boy character called Fudge, took the children outside one morning to look at Fudge's shadow. When they all returned to the same spot in the afternoon Fudge was alarmed because his shadow had moved, and had also shrunk. The children were invited to discuss what had happened and to help to solve Fudge's problem. Another example involved the use of two puppets, a boy called Mark and a girl called Kay. The teacher created a scenario where Mark was sad because he wanted to float one of his toys on water but did not have a boat. His friend Kay tried to sympathise with him but could not think of a way to solve the problem. She invited the children to explore the floating and sinking of objects to find a way to help Mark.

The examples from the pilot phase demonstrated that lessons seemed to work successfully with either just one puppet or with more than one puppet. Observations of the lessons and teachers' accounts indicated that puppets appeared to be motivating and to promote children's talk, as children were seen to pay attention, engage in the scenarios using the puppets and make contributions to discussion. This finding was evident with children across the age range (age 5 to 11).

Teachers also reported that children who were normally reserved were more willing to contribute when talking to the puppets, and many children were willing to share ideas and reveal misconceptions to puppets. Teachers found that they could use the puppets to discuss misconceptions, which could then be explored with investigative work.

The main research and development phase

Funding for the main research phase was only available for study within a narrow age range. Since puppets were more commonly used with 4 to7 year olds, we chose to work with children aged 7 to 11 years, to see whether our initial indications that puppets could be productive with older children would be confirmed. To our knowledge none of our teachers had any prior expertise in the use of puppets. The schools were selected to represent as wide a range as possible of social, cultural and ethnic backgrounds in the two locations. Of the 16 teachers involved at the beginning of this phase, three withdrew during the study due to internal school issues.

Before the teachers were initiated in the use of puppets they were asked to teach a typical science lesson, following their usual scheme of work, that could be observed and video-recorded. Where possible two groups of children in each class were also audio and/or video-recorded during periods of group activity to ascertain the nature of their interactions. Teachers were interviewed to obtain their views on the nature and value of children's talk and

details about how they taught science. These initial observations and interviews provided a baseline against which future lessons could be compared.

The 16 teachers attended preparatory meetings in each location to receive guidance on how puppets might be used effectively. Video material of the pilot study examples provided a useful stimulus for these main study teachers. The teachers selected puppets from the range available and after a period of several weeks, during which they could get used to using their puppets, a second science lesson was observed whilst they used one or more puppets as part of their teaching. Again they were requested to use the puppets in typical science lessons, taken from the usual scheme of work, rather than set up special puppets lessons that were separate from the usual curriculum. We wanted to be able to compare the talk in typical lessons, with and without puppets, and to ensure that the findings from the research would be relevant to other teachers working within their usual curriculum constraints. Teachers were interviewed again after their use of puppets to ascertain their views of the effectiveness of their practice, the response of the children to the puppets, and whether they believed their practice had changed using the puppets.

Small groups of children were interviewed where possible in each participating school. A total of 51 children were interviewed, of which 33 were aged 7 to 9 years and 18 were aged 10 to 11 years. Class teachers selected a group of children who provided a representative sample of the class, and who demonstrated a mixed response to the puppets (some who appeared positive, some negative). The children were interviewed either individually, in pairs or in small groups. Although there was an agreed interview schedule, the interviewers used their discretion and professional judgement in the exact wording, order and number of questions they asked in an attempt to ascertain responses from the children in a non-threatening way.

To summarise, the following data were collected and recordings were transcribed:

- Teachers were observed and video-recorded teaching two whole science lessons, one before using puppets and one using puppets; particular attention was paid to the introduction to the lesson and any plenary discussion, as these episodes were to include the main use of puppets.
- Where possible two groups of children in each class were audio and/or video-recorded during periods of group activity, at least one group of children was recorded in each lesson.
- Teachers were interviewed and video-recorded to ascertain their views on the impact of the puppets and the extent to which their practice might have changed.
- Small groups of children were interviewed and video-recorded to provide data on their perspective of the impact of the puppets.
- Teachers kept reflective diaries to enable them to capture their feelings about the use of puppets and record any significant classroom incidents at the time.

This range of data sources and collection methods allowed extensive cross-referencing and triangulation of the data. The findings reported here arise from analysis of all these data sources.

Data analysis and results: classroom interactions

Videos and transcripts of pilot puppet lessons were scrutinised and a provisional analysis was undertaken, informed by previous studies of talk (e.g. Mercer et al., 1999) and our own research on argumentative discourse (Simon, Erduran & Osborne, 2006; Maloney & Simon, 2006) that could enabled us to identify and categorise talk that focused on reasoning and argument. From this preliminary analysis two specific strategies were then developed to analyse the discourse in more detail. The first strategy was the construction of a coding scheme that would enable us to compare the nature of the discourse in pre-puppet and puppet

lessons, by studying the frequency of certain kinds of talk in each lesson. Our particular focus was on lesson introductions, as these were where puppets were most used. This focus enabled us to compare the ways in which the use of puppets might alter the nature of teacher and child contributions to the discourse in these introductory episodes of lessons. Though we were aware that the patterns of language use could be different according to the location of lessons within a topic, it was envisaged that such variations would be smoothed out when collating results from all the lessons observed. Our second strategy was to apply a time related observation schedule to episodes of small group discussion, using video and transcript together, in order to measure the amount of different kinds of talk that occurred when children worked together in groups. Limitations on recording all the discourse of these groups meant that transcripts were incomplete, thus detailed coding of transcripts was not possible. However, video-analysis, in which visual cues to the nature of interaction could be used as well as audio cues from the group as a whole, enabled us to measure the amount of learning conversations that took place between children by applying an observation schedule at 30-second time intervals (see below).

The nature of the discourse

During the analysis of pilot lessons a series of letter codes were produced that could be applied to distinctively different types of utterance occurring in the lessons. These codes reflected qualitative differences, such as questioning to elicit recall or questioning to promote reasoning. In the main study the codes were applied to a lesson transcript for a set of pre-puppet and puppet lessons by two researchers independently, and the coding system was refined. Each utterance that was in some way qualitatively different was assigned a code, indicating who spoke and the nature of the content. Thus each code consisted of two letters; the first indicated the speaker (T = teacher, P = puppet and C = child), the second letter

indicated the type of utterance made. New codes to cover all utterances were added as further transcripts were analysed, and following discussion and inter- reliability checks between researchers, a decision was made to further refine these codes and reduce them to 10 distinctive codes for each speaker (30 in all), before re-applying them to all the lesson transcripts (pre-puppet and puppet). The final list of codes used is shown in Figure 1.

[Insert Figure 1 here]

To illustrate how the coding was applied to the introductory discourse, Figures 2 and 3 show pre-puppet and puppet coded extracts for one of the Manchester teachers. The pre-puppet lesson (Figure 2) is characterised by a typical I-R-F question and answer pattern about the properties of food, where the teacher asks questions of a non-reasoning nature (TN) that invite recall responses (CR), which she then either repeats (TR), or simply acknowledges (TF). We make a distinction between these two kinds of non-challenging feedback response as they are qualitatively different. Repeating information supplied by the children (TR) falls within our overarching code of recall (Figure 1, R), whereas TF is used where a superficial feedback response is offered. In our quantitative analysis (see below) we have focused on the frequency of TR, as this most closely resembles typical I-R-F patterns of discourse. The teacher extends the I-R-F discourse when she wants to distribute the questions to involve more children, or when she wants to elicit another answer that is 'in her head'. Though the teacher occasionally asks 'why' questions, these are often to prompt *recall* of reasons rather than to stimulate reasoning, and are thus coded TN. The quality of the question 'why' in utterances 7, 19 and 25 is different in that the teacher is prompting the child to *reason*, thus these utterances are coded TQ. The responses are tentative however, as the children are still trying to guess the reason that the teacher wants, but they do make some attempt to think and reason (CA).

In the lesson using puppets (Figure 3), the science is also about attributing properties to material entities, though rather than foods, the context is rocks. The two puppets, Ruby and Rocky, are used to establish a narrative (PS) for setting the study of rocks in a meaningful context (climbing in their garden). They model arguments (PA), and ask for arguments from the children (PQ), which are forthcoming (CA). Though many responses by children are short single word utterances, they are contributing to arguments presented earlier and have thus been coded CA. There is a distinct use of encouragement and praise (PE) that is legitimised through the puppets, who have been given the role of being open to ideas from the children. The teacher (through the puppets) finally sets the scene for small group discussion by posing the problem, reiterated in many puppets lessons, of 'which puppet is right?' – in this case which of them has the best rock. Instead of posing a problem in this way, the teacher could simply have produced groups of rocks rather than foods and conducted the same kind of I-R-F discourse. It could be argued that the examples in Figures 2 and 3 are too different to use as a comparison; Figure 2 could be seen as a review of previous work, thus making an I-R-F pattern appropriate, whereas Figure 3 is about encouraging new ideas about the best rocks for a climbing area. However, close inspection of Figure 2 suggests that the teacher *is* trying to open up a new content area, but not by encouraging children's *own* ideas. Moreover, we would argue that from observations of lessons without the use of puppets, such encouragement of ideas typically does not occur; the essential content area (classification of rocks) would be 'delivered' in terms of review and closed questioning. In other words, the teacher in Figure 3 poses the problem because she has a puppet on her hand to pose it for her.

[Insert Figures 2 and 3 here]

Once the codes had been applied to the pre- puppet and puppet lessons transcripts for each teacher, we were able to see if there were any major differences in the nature of the discourse. In order to make statistical comparisons and minimise the effects of the variability of

individual teachers, the data were aggregated across all teachers for each code. Table 1 below shows the frequency of each code in both pre-puppet and puppet lessons. A Chi-squared test was administered to pairs of totals to enable judgements to be made about whether any differences in the data between the pre-puppet and puppet lessons were due to random variation or to some more significant cause. The areas of discourse where there were significant differences between the lessons are shown in bold in Table 1. In each case a Chi-squared test showed the differences to be highly significant ($p<0.001$).

[Insert Table 1 here]

The results show there is a difference in the nature of children's contributions when the puppets are used. The use of recall or argument was to a large extent determined by the opportunities presented by the teacher/puppet and the questions that teacher/puppet asked. The data show an increase in the children's use of argumentative responses (CA n=99 to n=244) and a decrease in their use of recall responses (CR n=389 to n=299) in the puppets lessons. Thus there were more opportunities for children to develop reasoning within episodes of argumentation in puppets lessons. These changes were evident in cases where the teacher already showed a high degree of opportunity for reasoning and argument before using puppets, as well as with the teachers where there was little opportunity for such talk.

There is a marked difference in the nature of teachers' questions when puppets are used. In the puppets lessons, questions could be asked by the teacher or by the puppet (PQ). The data show an increase in the teachers' use of reasoning questions (TQ/PQ, n=73 to n=263) and a decrease in their use of non-reasoning questions (TN/PN, n=388 to n=273). The teachers' questioning style created more opportunities for thinking in the puppets lessons. This increase in the use of reasoning questions is due to the way that puppets present problems to the class; through the puppets teachers were less likely to retain a transmission teaching style

based on recall questions and were more likely to change their questioning style to include more open, thought-provoking, questions.

There is also another marked difference in the teacher's style of discourse when puppets are used. In the puppets lessons the teacher could use puppets to give information (PR) or use argumentation and reasoning (PA). The data show an increase in the teachers' use of argumentation (TA/PA, n=111 to n=199) and a decrease in the extent to which they recalled information for the children (TR/PR, n= 329 to n=235) in the puppets lessons. The teachers' interaction with the children created more opportunities for engagement and challenge to thinking in the puppets lessons and most of this increase is attributed to argument used by the puppets. The increase in teacher argumentation, coupled with greater use of reasoning questions suggests a substantial shift in teaching style for these teachers when puppets were used.

Other differences in the teacher's style of discourse were noted when puppets were used; the code TS indicates when teachers (or puppets, PS) use a contextualising narrative to set a scenario for learning in a science lesson, thereby creating a purpose for the activity. The data show an increase in the teachers' use of story and narrative when puppets are used (TS/PS, n=4 to n=164). The data also show an increase in the extent to which teachers offer encouragement to children to make a contribution and to share their ideas in the lesson when puppets are used (TE/PE, n=132 to n=200). Both of these changes in teacher behaviour provide a more positive environment for learning in science lessons, a finding that is consistent with the data on children's engagement obtained from teacher children's interviews (see below).

The amount of different kinds of talk

The time-related observation schedule was developed to investigate the amount of different kinds of child-child interaction by creating a set of categories that could be applied to

episodes of small group activity and discussion. The combination of audible dialogue and visual cues enabled judgments to be made about the content of their conversations, according to the following sub-categories:

- Learning conversations – any conversation about scientific ideas or concepts.
- Practical conversations – any conversation relating to the practical experience of the lesson, such as use of equipment (pass me the scissors), turn taking and the order in which things should be done.
- Written work – any conversation relating to reading worksheets or recording information.
- Off task – any conversation that did not relate to science or the lesson in progress.

These categories were applied to the recordings of one group of children in each class at 30-second intervals, for both the pre-puppet and the puppet lessons, so that comparisons could be made in the amount of different kinds of conversation in the two lessons. When the data from these schedules were aggregated for all the lessons, the most significant difference (chi-square, $p<0.001$) was found in the amount of time spent in learning conversations and in practical conversations. Thus there was an increase in the amount of time that children spent discussing and arguing about science ideas and a decrease in the time that they talked about practical and procedural matters in the puppets lessons, this increase in the amount of small group talk involving reasoning also represents a change in the nature of children's talk.

[Insert Table 2 here]

Data analysis and results: interviews

Teacher Interviews and Reflective Diaries

A thematic analysis was also developed and applied to the transcripts of teacher interviews by two researchers. Additional data were provided by teachers' reflective diaries, in which

they recorded their views during the period that they used puppets, and a transcript from a follow up meeting for the two groups of teachers where issues and perceptions were shared. Quotations provided in this section are taken from all three sources of data.

The main themes were:

- Feelings about using the puppets
- Techniques for using puppets
- Children's responses to puppets
- Changes in professional practice

All of the teachers were very positive about using the puppets, saying they enjoyed using them in their lessons and were pleased with how the children had responded. Some teachers used two puppets in a lesson whilst others used only one. Though using two puppets enabled teachers to set up discussion by getting the puppets to put forward opposing views, teachers found that one puppet was much simpler to use whilst still making it possible to present problems and to set up cognitive conflict. Teachers planned the role of the puppet in terms of when the puppet was used and what the puppet would say. Often the teachers planned their lessons around a scenario where the puppets asked the children for help in solving a problem:

'I tend to use him (the puppet) most at the beginning, the introduction; setting the scene and getting the initial interest and talk going'.

Some teachers planned the character of the puppet beforehand whilst others let the character just emerge during their teaching, some modelled the puppets on characters from books or television programmes. Sometimes puppets were used to overcome stereotypes. For example, to overcome the view that boys are boisterous and girls quiet, one teacher developed two puppet characters that included a clever, studious boy puppet paired with a girl puppet who was loud and did not concentrate easily. The teacher emphasized the need

for the characters of the puppets to be well established as otherwise they would not be believable and would not engage the children.

Several teachers commented that children became more engaged in their science lessons since introducing the puppets. They noted that the children listened more and became more involved; they were more forthcoming and able to explain their ideas better; they paid attention more quickly and became interested in the lesson immediately; and more children engaged in conversations. Three teachers noted that the puppets improved the behaviour of their classes:

'Behavioural issues have just disappeared because the puppets are on the look out for good behaviour. In fact I have to be careful I don't run over time because the children are so engaged the lessons could last for hours. They just stay interested'.

Several teachers commented that children were more willing to express what they think when talking to a puppet. They wanted to answer the puppets' questions and were more prepared to think through ideas themselves. They became more confident in the way that they talked:

'The children … are able to talk about the puppet's ideas and let her (the puppet) be the one to blame if it (the idea) is not quite right'.

Many of the children who would not normally contribute to discussion took a more proactive role. In one class a child for whom English was an additional language became more confident and able to join in with the lessons. One teacher reported that the puppets engaged some of the 'needy children'; she described how one girl, who did not usually produce work, had made a poster for the puppet. The teacher said this was one of the most productive pieces of work the child had achieved. Two teachers reported that the behaviour of the children with the puppets could be a 'bit silly'. One explained that the class thought using the puppets was a 'licence to be silly at first'. However, this type of behaviour stopped

once the puppet had been used more frequently in the lessons. Two teachers suggested that some boys tended to respond better to male puppets, but no other teachers raised the issue of gender as a significant factor in the children's responses.

Most teachers noted that they had changed aspects of their practice since using the puppets. Six claimed to include a greater focus on pupils talking to each other in their lesson plans. Lessons included more planned discussion and more opportunities for the children to talk. One teacher described himself as 'tending to play a rather didactic (transmission) role in science', and using puppets helped him to change by getting the children to talk more to each other. Another teacher claimed to be a more interesting teacher in other subjects as a result of using puppets in science lessons.

Interviews with children

A thematic analysis of children's interviews was undertaken by studying the video-recordings and transcriptions, noting views that were frequently expressed. All of the children interviewed said they enjoyed having the puppets in the science lessons, with only two children (from the same teacher) expressing any reservations. Most children indicated that the puppets improved aspects of the lesson, such as making the lessons more enjoyable, and that puppets facilitated learning and feelings of confidence. Many of the children saw a strong connection between enjoyment and engagement:

'Before, when we didn't have puppets, right, the lessons were really boring, especially science, but now, right, with the puppets it is much more fun so we listen more'. (Boy aged 10).

Children felt that science lessons were easier to understand for a variety of reasons; the puppets used simpler language than the teacher; the puppets spoke more slowly and

explained more clearly; and the children had to think more in order to explain things to the puppets:

'The teacher already knows the answer anyway. So she's really just testing you. The puppet doesn't know the answer so we have to explain it in a way he will understand'. (Girl, aged 8).

Children also noted that the puppets asked more questions and created more opportunities for discussion than the teacher. 17 children said that they felt more confident when speaking to the puppet. They noted that the puppet was more of an equal and less judgemental than the teacher so that they could talk to it more readily:

'It's more comfortable talking to the puppet. If you get it wrong with the teacher she says "No". The puppet says "not really correct"'. (Girl, aged 11).

Discussion

Our research into the use of puppets in science classrooms has provided us with insights about the potential of this stimulating resource for promoting the 'right kind of talk' (Alexander, 2005) for productive learning. The research has provided evidence of puppets having an impact in three distinct ways: on the nature of the discourse in both teacher-child and child-child interactions, on the engagement and interest of children, and on teachers' beliefs and practice.

The kind of whole class discourse that really engages a large number of children in reasoning is not a prominent feature of UK classrooms (Alexander 2005). Whole class interactions are usually dominated by teachers' explanations, instructions, or highly structured question and answer sequences. Maintaining all the children's concentration and promoting reasoning during whole class discussion is a common problem for teachers. The use of puppets in whole class teaching, particularly in introductory sessions, can provide a

stimulus for talk that involves children in reasoning and argument and holds their attention. Essentially, using one or more puppets encourages the teachers to problematise the science; because teachers have to find roles for the puppets they create puppet characters that have 'problems' for the children to solve. Our conclusion is that because the teachers (using puppets) present problems rather than instructions, whole class discussion with pupils is more likely to lead to learning conversations about how the problem might be solved.

It became apparent through the interviews that children treated the puppets as though they were real characters in the class, and responded very positively to any problems faced by the puppets. Even though teachers operated the puppets, the use of puppets provided a context where classroom authority was not associated with the poser of problems (the puppet) and so the children interacted with them more readily.

Mercer et al 2004 claim: 'there are two main contexts in which spoken language can be related to the learning of science in schools....teacher-led interaction with pupils....peer group interaction' (p361); we believe the use of puppets provides a third context for classroom interaction that is productive for science learning because it introduces a different style of interpersonal relationship. In teacher-led interactions the teacher takes on a guiding role as a more knowledgeable individual who can help in the development of children's knowledge and in their induction into the discourse of science through appropriate use of language and questioning. Such a guiding role enables children to extend the limits of their learning, a point elaborated by those building on Vygotsky's work in terms of scaffolding (Wood, Bruner & Ross, 1976), guided construction of knowledge (Mercer, 1995) and dialogic teaching (Alexander, 2005). In peer group interaction, children have different opportunities for cognitive development through being exposed to reasoning that is near to but more successful than their own, the proximity of mental operations allowing for more instant internalisation. It is possible that the use of puppets enables children to develop their

intramental (individual) activity from intermental (social) activity (Vygotsky 1978) by mediating in two ways; first by the puppet posing problems that challenge thinking using language and ideas that are within the children's grasp but in advance of their reasoning (being devised by the 'expert' teacher), second by providing a social space for the children to articulate their reasoning by playing the 'expert' for the puppet ('we have to explain it to the puppet so he will understand'). In other words, the puppet can take the role of an expert and ask the right kinds of questions, or take the role of someone who needs expert advice. It is also possible that the kind of relationship that the children have with the puppets can be illuminated by studies such as those involving pretend play and interaction (Stambak, Ballion, Breaute & Rayna, 1985), which are informed by theories of socio-cognitive conflict and the construction of knowledge. Stambak et al found that in situations where children are free from the pressures of 'real' situations, they are more inclined to negotiate, take other's points of view into account, clarify their intentions and argue and justify their actions.

A major aim of the project was to provide a resource for teachers that would help them to enhance their practice by becoming more dialogic in their approach (Alexander, 2005). Teachers who may want to change their teaching style to incorporate more argumentation and more questions that encourage reasoning often do not see how to do this in practice. The introduction of the puppets could liberate them to teach in the way that they really want to teach. Even though some teachers might be resistant to changing their teaching style, our evidence suggests that as the puppets present problems to their children they might find that changes in teaching style are inescapable. A problem-centred focus for the lesson is likely to be accompanied by open questions, argumentation and justification of ideas as part of the process of solving the problem. In this way teachers could find that a change in their teaching style is an incidental but inevitable outcome of using puppets, whatever their initial predisposition.

The literature on teacher change is consistent in suggesting that change in teacher practice can be difficult to achieve in a short period of time (e.g. Adey, 2004; Fullan, 2001). However we found that using the puppets had a greater effect on teacher practice over a short period of time than we would have anticipated. We know from ongoing contact with some of the teachers in the pilot phase that changes in their practice have been sustained and that they have continued to use puppets in their science teaching. These changes occurred after only a short preparation session and with teachers working entirely within their usual science curriculum. In this respect the introduction of puppets appears to compare favourably with some other innovations in science education, where more far-reaching changes are viewed as necessary for the innovation to be successful.

Future directions

The puppets research appears to have the potential to make a positive impact on science teaching in primary/elementary schools. Funding has recently been secured to support a substantial programme of professional development for teachers, together with provision of resources including puppets and scenarios in which the puppets can operate. Several factors have emerged from the research that appear to be relevant in ensuring that this programme of professional development is effective. These factors include:

- The project is entirely located within existing curricula. Teachers do not have to put on special puppets lessons that fall outside the usual science content of the curriculum. They do not have to invest any additional time in using puppets but can incorporate puppets within their current schemes of work, addressing the requirements of the national curriculum for science using more dialogic approaches.

- The training programme and level of commitment that teachers are required to make to the project are modest. Teachers do not need to invest extensive amounts of time, energy or resources in introducing puppets to their school.
- Teachers do not need to make major shifts in their professional practice before they try the approach in their teaching. Although involvement in the project may well lead to changes in professional values, beliefs and practice, this is not a pre-requisite for using puppets successfully.

These factors lead us to believe that teachers are likely to welcome the project and that professional development decision-makers will be keen to gain access to the project for their teachers. As teachers strive to adopt new, more dialogic practices and make science more meaningful, the use of puppets may help to build classroom discourse that is more collective, reciprocal, supportive and purposeful (Alexander 2005).

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Figure 1. Codes used in analysing the nature of discourse in science lessons

Code	Meaning	Illustration
Q	Reasoned questions	Open questions that present a problem. Questions that require a reasoned answer.
N	Non-reasoned questions	Questions that do not require a reasoned answer. Closed, rhetorical or non-science questions.
L	Language	Features of language; focus on use of words rather than ideas and concepts – e.g. correcting grammar or introducing vocabulary.
A	Argument-ation	Use of ideas to challenge or justify a point of view.
F	Feedback	Offers a superficial response that doesn't promote thinking or challenge for further explanation.
E	Encourages	Offers praise or positive endorsement.
R	Recall	Recalls of information from memory or accesses previously learned knowledge.
O	Observation	Describes something in the classroom. Reads from worksheet or the board.
P	Procedure	Gives information or instruction, or discusses things that relate to the procedure to be followed.
S	Story & Character	Creates a contextualising narrative in which scientific concepts can be applied to give the lesson a sense of purpose.

Figure 2. Coded transcript for Manchester teacher: pre-puppet lesson.

Speaker	Content of utterance	Code applied
1 Teacher	Think back to yesterday and why we eat, well what did we say? What were the two reasons why we eat food, William?	TN
2 William	To grow	CR
3 Teacher	One reason was to help you grow and what, can you remember the other reason, Ruth?	TR TN
4 Ruth	To help you concentrate	CR
5 Teacher	Yes it was and can you remember, why it could help you concentrate, Caitlyn?	TF TN
6 Caitlyn	It gives you energy.	CR
7 Teacher	It gives you energy. So this group [of children] have grouped those things together. What about these, why do you think they have grouped these together. Daniel?	TR TQ
8 Daniel	Erm, is it because they are not that good for you, but it is a bit.	CA
9 Teacher	What does it provide our bodies with?	TN
10 Child	Milk	CR
11 Teacher	It is milk absolutely, but what do you think they allow our bodies to do, Emma?	TR TN
12 Emma	Fat	CR
13 Teacher	They have fats in. What do you think those fats may	TR

	allow our bodies to do Sam?	TN
14 Sam	Keep healthy	CR
15 Teacher	Keeps us healthy, what do you think they do for us Elise?	TR TN
16 Elise	Energy	CR
17 Teacher	It gives us energy, anything else Hannah?	TR, TN
18 Hannah	Grow	CR
19 Teacher	Help us to grow, it might give us energy and help us to grow. What about these, we've got tomatoes and grapes, why have these been grouped together, William?	TR TQ
20 William	Because they are all the same	CA
21 Teacher	What are they?	TN
22 William	They are vegetables	CL
23 Teacher	Why do you think these might help, would these help our bodies, Caitlyn?	TN
24 Caitlyn	Yes, they would help our bodies	CR
25 Teacher	Why do you think so?	TQ
26 Caitlyn	Because they are healthy	CA
27 Teacher	Why are they? What do you think they do for our bodies? Charlotte	TN
28 Charlotte	They help us grow	CR
29 Teacher	They help us grow, yes. We've got food here that gives us energy, we've got foods here that help us to grow.	TR

Figure 3. Coded transcript for Manchester teacher: puppets lesson (Ruby and Rocky are puppets use by the teacher)

Speaker	Content of utterance	Code applied
1 Ruby	One thing Rocky and I have already talked about for our dream garden is, not a climbing fame as such, because we've had a look in your garden outside and we've seen something that has given us an idea.	PS PS
2 Rocky	Yeah, we saw that you have lots of large rocks in your garden and we were talking about what a good idea it would be to have, not a climbing frame, but some climbing rocks.	PS PS
3 Ruby	Yes, we thought it would be good to have some rocks piled up that we, and our friends, and you, if you come to our house, can climb on.	PS
4 Rocky	Yeah, so we are thinking rocks. A climbing area made of rocks.	PS
5 Ruby	We've had some rocks sent to us and these rocks are gorgeous.	PS
6 Rocky	Well, some of them are. Some of them are nice and some of them I wouldn't use of a rock climbing area.	PR PA
7 Ruby	Well, there are some that I would use and I think we can, there are some of these rocks we can use.	PA
9 Rocky	And I think some of these rocks won't work, on a nice climbing area.	PA

10 Ruby	Well what do you think a nice rock climbing area should have, and what should it look like. What do you think?	PQ
11 Rocky	What do you think the rocks need to be like in order to make a really good climbing area?	PQ
12 Ruby	Yeah, look they can tell us. Let me have a look…let me have a look…Elise.	PE
13 Elise	Well, they need to be strong so when they climb on them they don't break.	CA
14 Ruby	Oh, they need to be strong so when they, we climb on them they don't break.	PR
15 Rocky	Good idea Elise, let me see who else has an idea. Daniel?	PE PQ
16 Daniel	You could use soap stone.	CA
17 Rocky	Daniel, just hold on a minute cos we are asking what characteristics these rocks need to have. What do they need to be like?	PQ
18 Daniel	Hard.	CA
19 Rocky	So Daniel's saying hard.	PR
20 Ruby	Good. Anything else? Charles?	PE PQ
21 Charles	Flat, strong and hard.	CA
22 Ruby	Flat, strong and hard. Anything else? Robert?	PR PQ
23 Robert	Waterproof, because if you go on them when they are not waterproof, like limestone, it could go, if they are	CA

	still water in them you could slip, or because there is holes in it, it could just break away.	CA
24 Ruby	Robert that is a really good characteristic that I hadn't thought of. So we've got flat, strong, hard, we've got the fact that they need to be- Robert used the word waterproof.	PE PR
25 Rocky	Anything else, Joseph?	PQ
26 Joseph	You haven't got that it needs to be no sharp pointed edges because you could easily cut yourself.	CA CA
	……[*more ideas from the class]*	
38 Ruby	Lots of ideas to think about there. Really excellent.	PE
39 Rocky	The rocks that we've looked at, we've got a bit of a problem, because I've chosen a rock that I think is going to be really good for a rock climbing frame.	PS PS
40 Ruby	And I've chosen a different rock. Your teacher, in a minute, will show you the rocks we have chosen. You see I know I'm right, and my rock is the best one.	PS PA
41 Rocky	What did you say? I know the rock I have chosen is definitely the right rock for the rock climbing frame. And the rock that Ruby has chosen is just no good at all.	PA
42 Ruby	Ha	PA
43 Rocky	What was that?	PA
44 Ruby	Nothing, nothing, but you are going to have a go at helping us decide on a good rock for the climbing area so erm, bye, see you later.	PQ

Table 1: Frequency of different types of classroom discourse in pre-puppet and puppet lessons

Child codes	Pre-lesson	Puppet lesson		Teacher codes	Pre-lesson	Puppet lesson		Puppet codes	Puppet lesson	Total puppet (T+P)
CQ	1	10		TQ	**73**	143		PQ	120	**263**
CN	3	17		TN	**388**	204		PN	69	**273**
CL	4	5		TL	62	35		PL	30	65
CA	**99**	**244**		TA	**111**	83		PA	116	**199**
CF	1	6		TF	157	132		PF	40	172
CE	0	1		TE	**132**	103		PE	97	**200**
CR	**389**	**299**		TR	**329**	198		PR	37	**235**
CO	118	115		TO	76	50		PO	25	75
CP	7	13		TP	326	297		PP	29	326
CS	0	17		TS	**4**	66		PS	98	**164**

Key:

Codes are shown in the top row, using codes from Figure 1, where C=child, T=teacher and P=puppet (teacher talking through the puppet).

Table 2: Comparison between amount of time spent on learning conversations and practical procedures in child-child interactions.

Lesson	Time spent in Learning conversations (minutes)	Time spent in Practical procedure (minutes)
Pre-puppets	48.5	72.5
Puppets	128.5	30